Department of Defense

High Level Architecture

Rules

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Introduction

The High Level Architecture (HLA) is defined by a set of rules, an interface specification, and an object model template (OMT). This paper provides an overview of the HLA. General principles defining the HLA are described and the set of rules which apply to HLA federations and federates are delineated. Each rule is then described and the rationale for its inclusion is discussed.

The overall objective of the DoD common technical framework, which includes the HLA, is to support interoperability and reuse. The HLA provides the structural basis for interoperability; most of the rules described here have been included for that reason. However, it is recognized that the HLA is necessary but not sufficient for interoperability. The other two legs of the common technical framework, the Conceptual Models of the Mission Space and Data Standardization, address other, equally important aspects of interoperability.

Summary of the HLA Rules

Rules for federations are:

1 Federations shall have an HLA Federation Object Model (FOM), documented in accordance with the HLA Object Model Template (OMT).

2 In a federation, all representation of objects in the FOM shall be in the federates, not in the runtime infrastructure (RTI).

3 During a federation execution, all exchange of FOM data among federates shall occur via the RTI.

4 During a federation execution, federates shall interact with the runtime infrastructure (RTI) in accordance with the HLA interface specification.

5 During a federation execution, an attribute of an instance of an object shall be owned by only one federate at any given time.

Rules for federates are:

6 Federates shall have an HLA Simulation Object Model (SOM), documented in accordance with the HLA Object Model Template (OMT).

7 Federates shall be able to update and/or reflect any attributes of objects in their SOM and send and/or receive SOM object interactions externally, as specified in their SOM.

8 Federates shall be able to transfer and/or accept ownership of attributes dynamically during a federation execution, as specified in their SOM.

9 Federates shall be able to vary the conditions (e.g., thresholds) under which they provide updates of attributes of objects, as specified in their SOM.

10 Federates shall be able to manage local time in a way which will allow them to coordinate data exchange with other members of a federation.

Federation Rules

This section describes the five rules that apply to HLA federations. Each rule is described along with the rationale for its inclusion.

Federations shall have an HLA Federation Object Model (FOM), documented in accordance with the HLA Object Model Template (OMT). (Rule 1)

The FOM documents the agreement among federates on data to be exchanged at runtime and the conditions of the data exchange (e.g., updates to be sent when changes exceed a certain value). As such, the FOM is an essential element in defining a federation. The HLA does not prescribe which data are included in the FOM (this is the responsibility of the federation user and developer). The HLA does require that FOMs be documented in a prescribed format (HLA Object Model Template [OMT]) to support reuse of a federation (FOM) by new users for their own purposes.

The formalization of agreements for information exchange is an important element of the HLA. The HLA is domain independent and can be used to support federations for a wide variety of uses. The FOM is the means for specifying the particular data exchange for a given application of the HLA. By formalizing the development of these agreements and requiring that the results be documented in a common format, the HLA provides the means for understanding the key elements of a federation and a vehicle for assisting in the reuse of the federation, in whole or part. Such reuse is a goal of the HLA. In addition, the FOM provides the basis for some of the data used to initialize the runtime infrastructure (RTI) for the federation.

In a federation, all representation of objects in the FOM shall be in the federates, not in the runtime infrastructure (RTI). (Rule 2)

One basic idea behind the HLA is to separate simulation-specific functionality from general purpose supporting infrastructure. In the HLA, representation of simulated objects (e.g., ownership of attributes, where "ownership" is defined as the having responsibility to update values) is done in the simulations (or, more generally, the federates); the RTI provides the distributed-operating-system-like functionality needed to support interaction of objects across the federation. All object attributes are owned by the federates, not by the RTI.

This separation of simulation functionality from federation support services was done for several reasons. First, the RTI services are intended to be the basic set of broadly reusable capabilities needed to support federations across the widest range of DoD (and other) users. These are essentially coordination and management services supporting federation operations, time coordination, data distribution etc. Because they apply across a range of HLA applications, these can most cost effectively be provided once in the form of services to the applications rather than by the applications themselves. This has the added advantage of freeing the federates to focus on their primary objective of representing objects to meet the needs of a user or application domain. This approach alleviates the developers of simulations from investing time and resources in these basic common services. The RTI may use data

about object attributes and interactions to support RTI services (e.g., declaration management), but these are merely used by the RTI, not changed.

During a federation execution, all exchange of FOM data among federates shall occur via the RTI. (Rule 3)

The HLA specifies a set of interfaces to services in the runtime infrastructure (RTI) to support coordinated exchange of object attributes values and interactions in accordance with the FOM for that federation. Under the HLA, interactions among objects in participating federations is executed by the exchange of data via the RTI services. Based on the FOM, federates provide information about what information they will provide and require, along with attribute and interaction data to the RTI corresponding to the changing state of objects in the federate. The RTI then provides the coordination, synchronization and the data exchange among the federates to permit a coherent execution of the federation.

Ensuring the right data is provided at the right times, and that the data is used in a substantively correct way is the responsibility of the federates; the RTI assures that the data is delivered to the using federates in accordance with their declared requirements (which data, reliability of transport, event ordering, etc.) to provide a common view of shared data across the federations as specified in the FOM.

In order to assure that the coordination needs of the distributed applications (federations) are met in a consistent way across all participants in a federation and over the life of a federation execution, RTI services must be used. If a federation were to exchange data representing state changes of shared objects or interactions among objects outside of the RTI service suite, the coherency of the distributed application would be violated. The reason for providing common runtime infrastructure services to federations is to commonly provide the needed basic functionality to permit coherency in data exchange among the simulations, reducing costs of development and formation of new federations.

During a federation execution, federates shall interact with the runtime infrastructure (RTI) in accordance with the HLA interface specification. (Rule 4)

The HLA provides a standard specification for accessing RTI services to support interfaces between federates and the RTI (see the HLA Interface Specification). Federates use these standard interfaces to interact with the RTI. This interface specification defines how simulations will interact with the infrastructure. However, since the interface and the RTI will be used for a wide variety of applications requiring data exchange of diverse characteristics, it says nothing about the specific object data to be exchanged over the interface. Data exchange requirements between federates are defined in the FOM.

By requiring a standardized, common interface between federates and the RTI, along with a common API, the HLA allows for independent development and implementation. Simulations can work independently and develop interfaces to the RTI, without regard to RTI implementation, and RTI developments can proceed without explicit consideration of simulation development. The separation of the interfaces from the object data exchange requirements allows for the reuse of a common interface specification across the broad spectrum of DoD (and non-DoD) applications, with specific application needs tailored through the FOM mechanism.

During a federation execution, an attribute of an instance of an object shall be owned by only one federate at any given time. (Rule 5)

The HLA allows for different federates to own different attributes of the same object (e.g., a simulation of an aircraft might own the location of a the airborne sensor while other attributes of the sensor might be owned by a sensor system model). To ensure data coherency across the federation, the HLA allows only one federate to own (have the right to change the value of) the attribute of an object at any given time. The HLA does provide the mechanism to transfer ownership dynamically during execution from one federate to another.

By defining object ownership at the attribute level and providing the tools to hand-off ownership during execution, the HLA provides a flexible toolset for using various combinations of simulations to meet user needs.

Federate Rules

This section describes the five rules which apply to HLA federates. Each rule is described, along with the rationale for its inclusion.

Federates shall have an HLA Simulation Object Model (SOM), documented in accordance with the HLA Object Model Template (OMT). (Rule 6)

Federates are simulations (a method for implementing a model over time) or other applications (including simulation managers, data collectors, live entity interfaces, and passive viewers) participating in a federation. The HLA requires that each federate have an HLA simulation object model (SOM). The HLA SOM includes those objects, attributes, and interactions of the federate that can be made public in a federation.

The HLA does not prescribe which data are included in the SOM; this is the responsibility of the simulation developer. The HLA does require that SOMs be documented in a prescribed format (HLA Object Model Template).

A major of goal of the HLA is to support interoperability and reuse of simulations. The HLA addresses this by providing reuse at the level of simulations (or, more generally, federates), allowing access to the representations in those simulations.

Lack of cost-effective access to information about the object representations available in federates is an inhibitor to reuse. The requirement for a SOM addresses this by requiring federates to document the minimum essential, salient aspects of their capabilities to allow for easy identification of the federate's potential application in new federations. It is understood that the full set of information required by a potential user will go well beyond the SOM contents, but it is believed that by providing easy access to characterizations of simulations based on reuse potential, users can more effectively make the decision of whether to invest in further assessment of applicability of the simulation to their application (through simulation descriptions available in the Modeling and Simulation Resource Repository (MSRR), simulation specific documentation, or direct interaction with the simulation developer).

Given the emphasis on reuse, it was assumed that developing and maintaining an accurate and usable statement of information supporting reuse would be a high priority for individual simulation developers, whose success will be measured in part by the extent to which their simulation supports a wide variety of user applications.

Federates shall be able to update and/or reflect any attributes of objects in their SOM and send and/or receive SOM object interactions externally, as specified in their SOM. (Rule 7)

The HLA allows federates to make object representations and interactions developed for internal use available as part of federation executions for external use with objects represented in other federates. These capabilities for external interaction will be documented in the SOM for the federate. These federate capabilities include the obligation to export values of attributes of objects which are calculated internally in the federate and have the ability to exercise these interactions with objects represented externally (i.e., initiate, sensing, and reacting). By designing federates from the outset with the ability to present internal objects/attributes/interactions externally, the mechanisms for reuse of the simulation will be in place from the start.

Federates shall be able to transfer and/or accept ownership of attributes dynamically during a federation execution, as specified in their SOM. (Rule 8)

The HLA allows for different federates to own different attributes of the same object (e.g., a simulation of an aircraft might own the location of the airborne sensor while other attributes of the sensor might be owned by a sensor system model). With this capability, it is possible to allow a simulation designed for one purpose to be coupled with one designed for another purpose to meet a new requirement. By building in the capability to transfer and accept ownership of object attributes, simulations designed with the HLA in mind are providing the basic structural tools to become a federate in the widest possible range of future federations. The object/attributes of a federate which can be either owned or reflected, and which can be dynamically transferred during execution are documented in the SOM for that federate.

Federates shall be able to vary the conditions (e.g., thresholds) under which they provide updates of attributes of objects, as specified in their SOM. (Rule 9)

The HLA permits federates to own (i.e., produce updated values for) attributes of objects represented in the simulation, and then make those values available to other federates through the RTI. Different federations may specify different conditions under which attributes will be updated (at some specified rate, when the amount of change in value exceeds a specified threshold such as altitude changes of more than 1000 feet, etc.) . Widely usable simulations will have the capability to adjust the conditions under which they export their public attributes to support the requirements of different federations. The conditions applicable to the update of specific object attributes of a given federate are documented in the SOM for that federate.

Federates shall be able to manage local time in a way which will allow them to coordinate data exchange with other members of a federation. (Rule 10)

The High Level Architecture time management structure is intended to support interoperability among federates utilizing different internal time management mechanisms. The HLA supports these capabilities provided federates adhere to certain requirements necessary to realize each service. To achieve these goals, a *single,* unifying approach to time management is being developed to provide time management interoperability among disparate federates. Different categories of simulations are viewed as special cases in this unified structure, and typically use

only a subset of the RTI's full capability. Federates need not explicitly indicate to the RTI the particular time flow mechanism (time stepped, event driven, independent time advance, optimistic event driven) being used within the federate, but will utilize the RTI services (including Time Management) which are appropriate for coordination of data exchange with other federates. This rule states that a federate must manage its local time in a way which allows for coordination with other federation members to meet requirements of the federation, using RTI time management when and if appropriate.